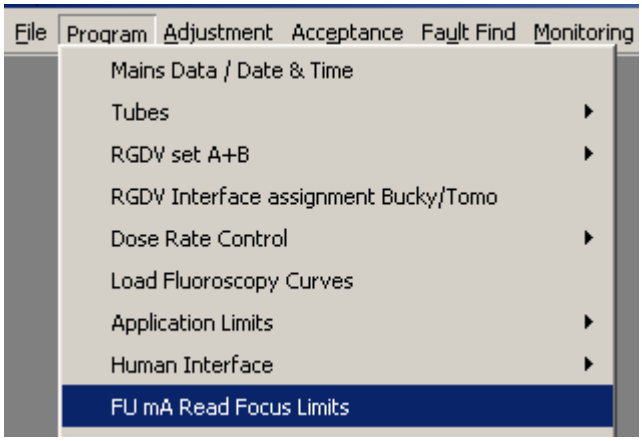
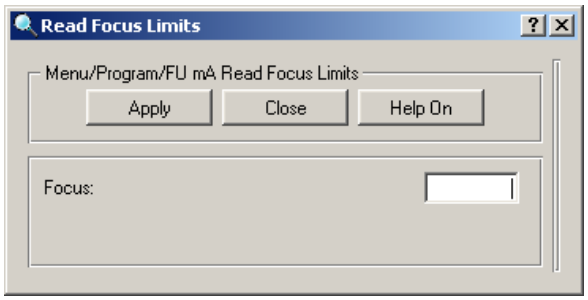
OPTIMUS adaptation sequence (using AgenT)

Prerequisites to adapt a tube:

At least one registration device (RGDV set A+B) and a tube type must be programmed (followed by a generator reset) to get the generator into a standby condition for adaptation.

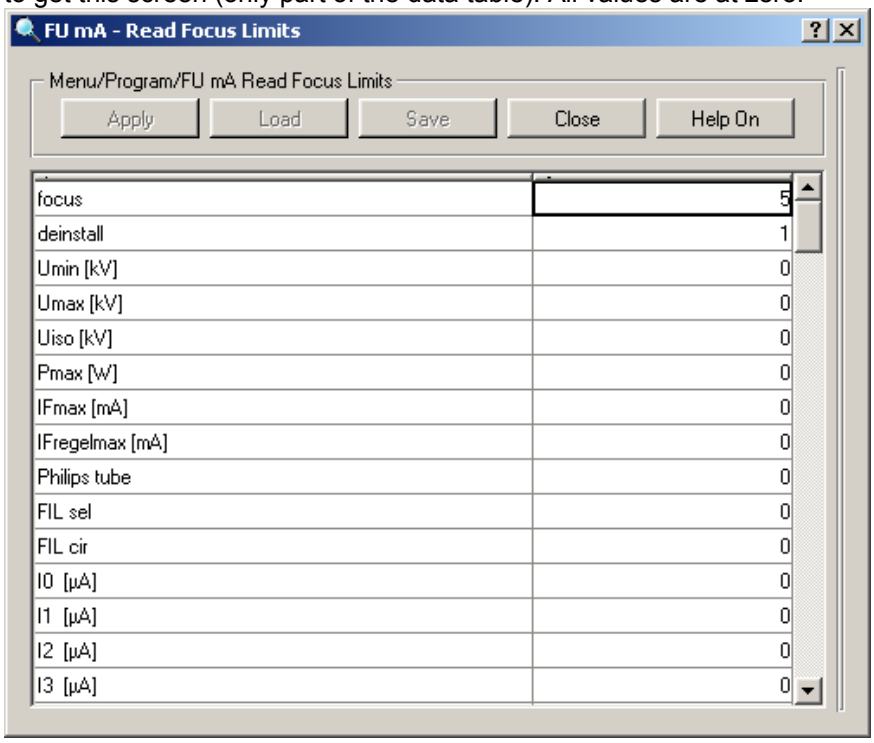
If no tube is programmed the tables of FU-mA (function unit mA_control EZ119) will be empty. Select



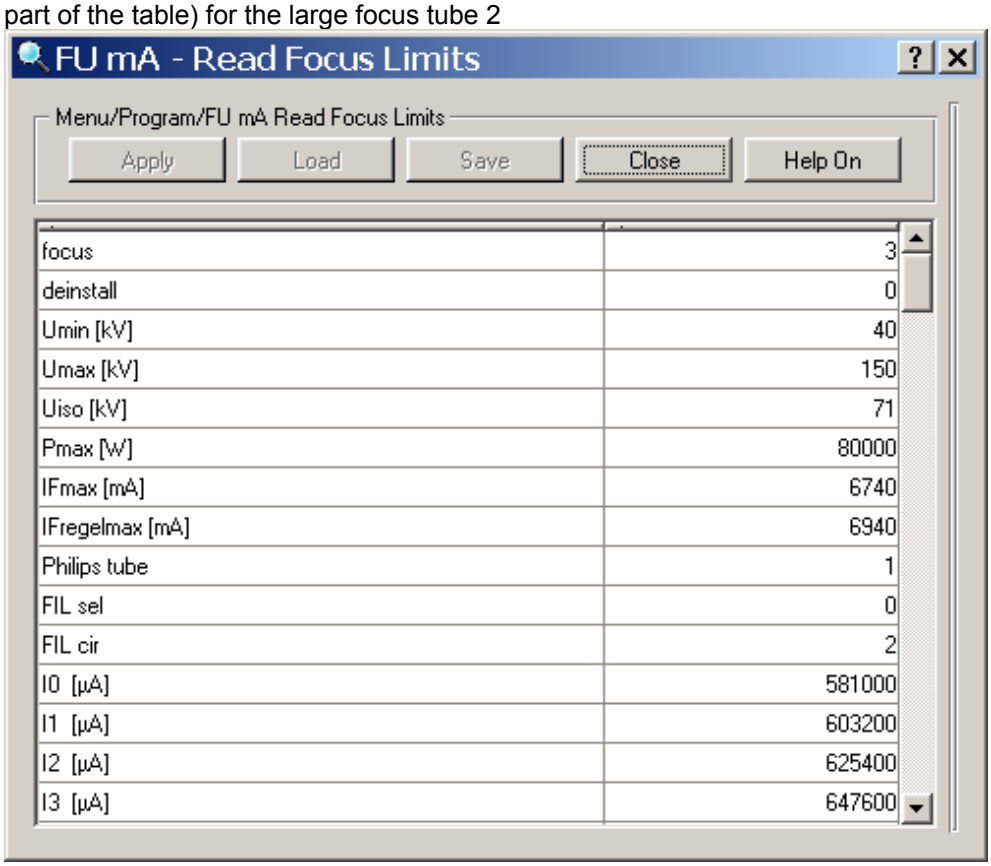


Type in:**1**, 3, 5 for **large focus** tube **1**, 2, 3 or **2**, 4, 6 for **small focus** tube **1**, 2, 3

to get this screen (only part of the data table). All values are at zero.

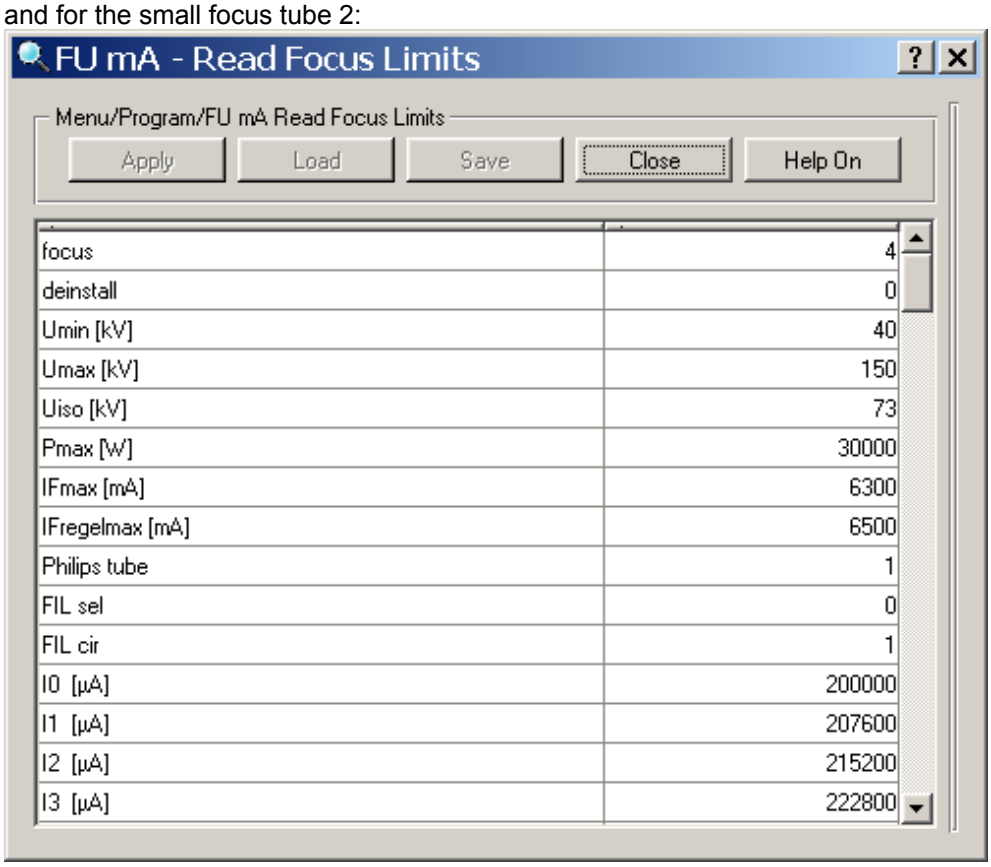


Once a tube is programmed the tables look like this (example of an SRO33/100 with an Optimus 80), only part of the table) for the large focus tube 2



focus	3
deinstall	0
Umin [kV]	40
Umax [kV]	150
Uiso [kV]	71
Pmax [W]	80000
IFmax [mA]	6740
IFregelmax [mA]	6940
Philips tube	1
FIL sel	0
FIL cir	2
I0 [µA]	581000
I1 [µA]	603200
I2 [µA]	625400
I3 [µA]	647600

and for the small focus tube 2:



focus	4
deinstall	0
Umin [kV]	40
Umax [kV]	150
Uiso [kV]	73
Pmax [W]	30000
IFmax [mA]	6300
IFregelmax [mA]	6500
Philips tube	1
FIL sel	0
FIL cir	1
I0 [µA]	200000
I1 [µA]	207600
I2 [µA]	215200
I3 [µA]	222800

Both filaments get default max mA data between 40...150kV represented by the **I0, I1, ... I110 [µA]** values. These are the absolute kV dependent emission current limits. They might be overridden if e.g. the max emission current of the generator is smaller (650mA Optimus 50kW, 900mA Optimus 65kW).

Other limits within which the tube will be adapted are

Pmax [W] max focus load (if not overridden by the max generator power)
Ifmax [mA] max filament current limit

Other values which might change during the adaptation process:

Ifregelmax [mA] is a max value which might temporarily be used for fast mA control, typically I_f max + 200mA
Uiso [kV] is the default kV value from which on (going to the higher kV stages) the filament current can be decreased to achieve always the max possible emission current

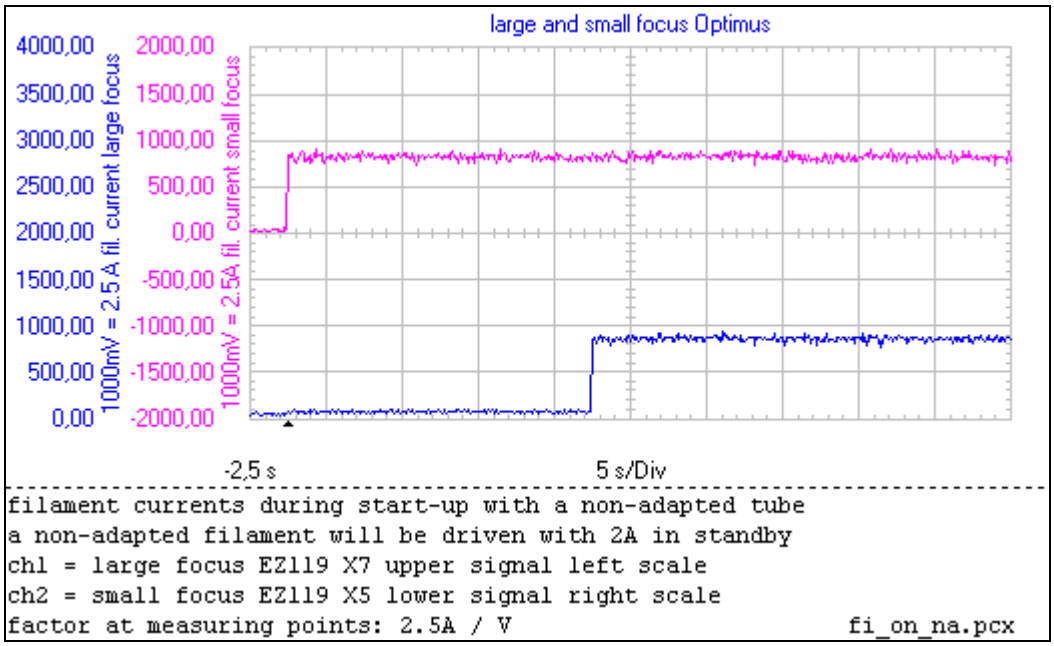
After loading of the tube data and assigning the tube to at least one RGDV the generator must be reset.

It takes longer for the generator to come up if filaments are not adapted; once adaptation has been carried out the up time is much shorter.

A non-adapted tube will get a standby current of 2A at both filaments; with an oscilloscope one can monitor the currents coming up at turn-on.

Hint: Numbers in the circles correspond to the overview chart last page.

1



The control desk will display "Test" in the exposure parameter display to indicate that the selected focus is not adapted.

In this stage one can already switch exposures at any kV stage and any mAs with a special mAs technique (see appendix A **mA_control EZ119 functions conditioning mode**), e.g. to warm up the tube before adaptation.
Conditioning is recommended to avoid arcing problems during adaptation.

In the non-adapted status one will face the following symptoms due to the calculation tables still missing:

- APR cannot be selected
- No AEC and no non-AEC technique can be selected
- Variofocus cannot be selected (both filaments must be adapted).
- Fluoroscopy cannot be released

Five filament current values are important to know:

1) I_f min — minimum filament current 500mA which will always be present to feed a grid switch control unit (not for Optimus RAD - R/F- C)
2) I_f standby — standby filament current (determined during the 2nd exposure of the adaptation)
3) I_f max — maximum filament current
4) I_f regelmax — maximum filament current + xxx mA offset filament current for fast emission current control in case of mA deviations
5) I_f boost — boost current = maximum filament current (I_f max) + 2 A

Once adaptation is started via AGenT and by pushing PREP and EXP the filament current of the non-selected focus will be turned off.
The generator switches automatically to the focus, which has been selected for adaptation.

(2)

The selected filament will get only 500mA for a certain time to let it cool down.

With the first exposure at 40kV the mA measuring circuit offset will be measured.
The offset value combines a basic 4mA current driven by the voltage to frequency circuit (waveform see Appendix B) and the additional mA driven by the high tension divider circuit, which also passes the mA measuring resistor.

(3)

This offset mA value will be subtracted from the actual value of the measured mA value during fluoro or exposure.

(4) >> (5)

The second exposure of the adaptation process is 6 seconds long.
At 40kV FU-mA determines a filament current which is necessary to drive an emission current of 100µA.
The filament current value, which has been measured, is the individual standby filament current.
(These values are higher compared to predecessor generators; they were based on a 40µA emission current).

(6)

The filament will now be driven up to its maximum current I_f max and will be kept some seconds to get a stable temperature.

Starting at 40kV with slight kV increments FU-mA measures the mA values at each kV stage set.
All exposures of the following sequence will be about 10ms long.

The kV values are increased to a max value to prevent focus overloads.
In the beginning of the adaptation process it will be below 50kV.

Once the focus load limit is attained the filament current will be decreased, a little pause allows the filament temperature to cool down.

A new series of exposures starts again at 40kV with kV increments up to the max focus load.

(7)

At a certain point (once the filament current value is low enough) the max kV value, which has been programmed, can be switched.
From this point on the kV discharge time will get longer with each filament current decrement.
Therefore is important to use CTRL_X_C/ EZX74 as trigger signal.
Using the kV waveform as trigger will fail in the low filament current value exposures.

120 ... 130 exposures will be switched until the filament current is down from its max value in the beginning to the standby value which has been determined before.

(8)

Now FU-mA calculates the kV dependent filament <-> emission current tables.
It also evaluates the new value of the U_{iso}.

The kV value U_{iso} is the kV stage at which the boost adaptation takes place.

(9)

First the positive boost will be carried out. The kV will start with the just calculated U_{iso} value.
Once the kV are up the filament current value will change from its standby value to the
I_f boost value = maximum filament current (I_f max) + 2 A.

FU-mA measures the rising emission current as well as the time it takes to be at the max emission current specified for the U_{iso} value.
This timetable is needed to get the temperature of a filament up as fast as possible if a higher mA value is required.

(10)

The filament current is reduced to I_f min 500mA for a certain time to let it cool faster, afterwards it returns back to its standby value.

(11)

A new function of the Optimus is the negative boosting.

(12)

The filament gets the max current I_f max for a certain time to have a stable temperature at the filament.
Once the kV are up at the U_{iso} value

(13)

the filament current instantly drops down to the I_f min value of 500mA.

FU-mA measures the falling emission current as well as the time it takes to be down at 100µA.
This timetable is needed to get the temperature of a filament down as fast as possible if a lower mA value is required.

(14)

Adaptation is finished. FU-mA now drives the standby filament current.

The PC will beep; the generator has to be reset now.

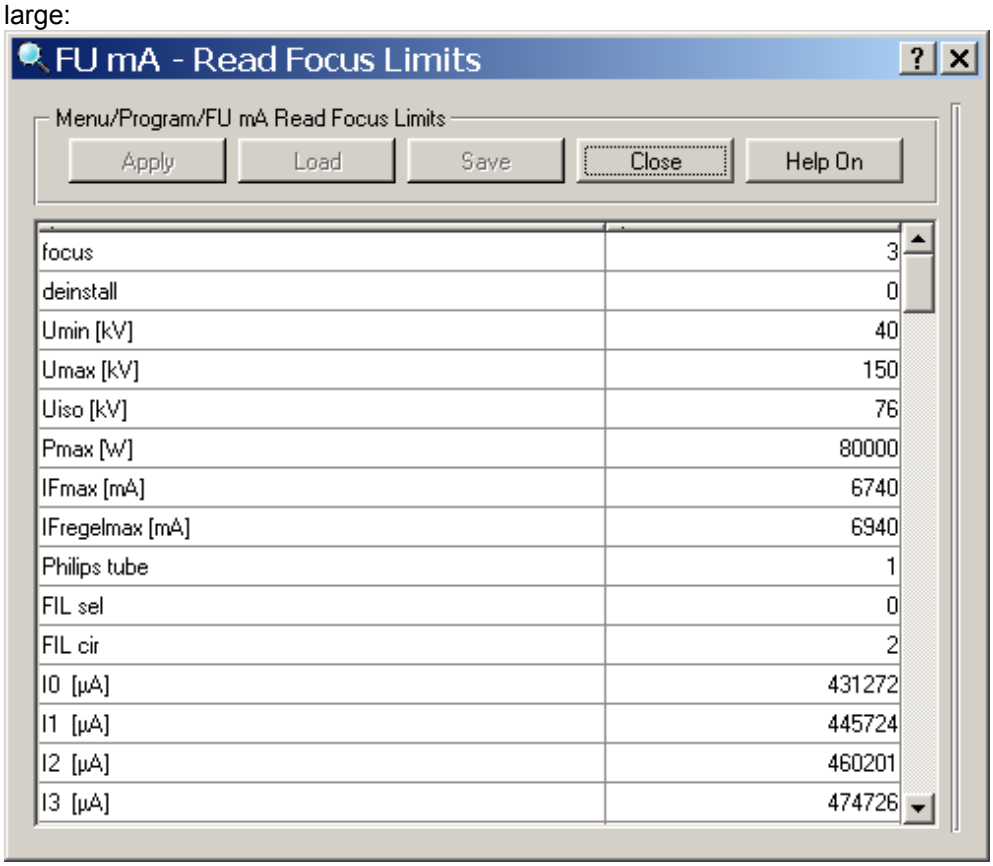
The large focus kV dependent emission current values dropped (tube with a filament problem: some of the filament loops are welded which lets the large focus have a smaller emission; this example shows that a system can still work with such a tube).

The small focus emission current values remained the same.

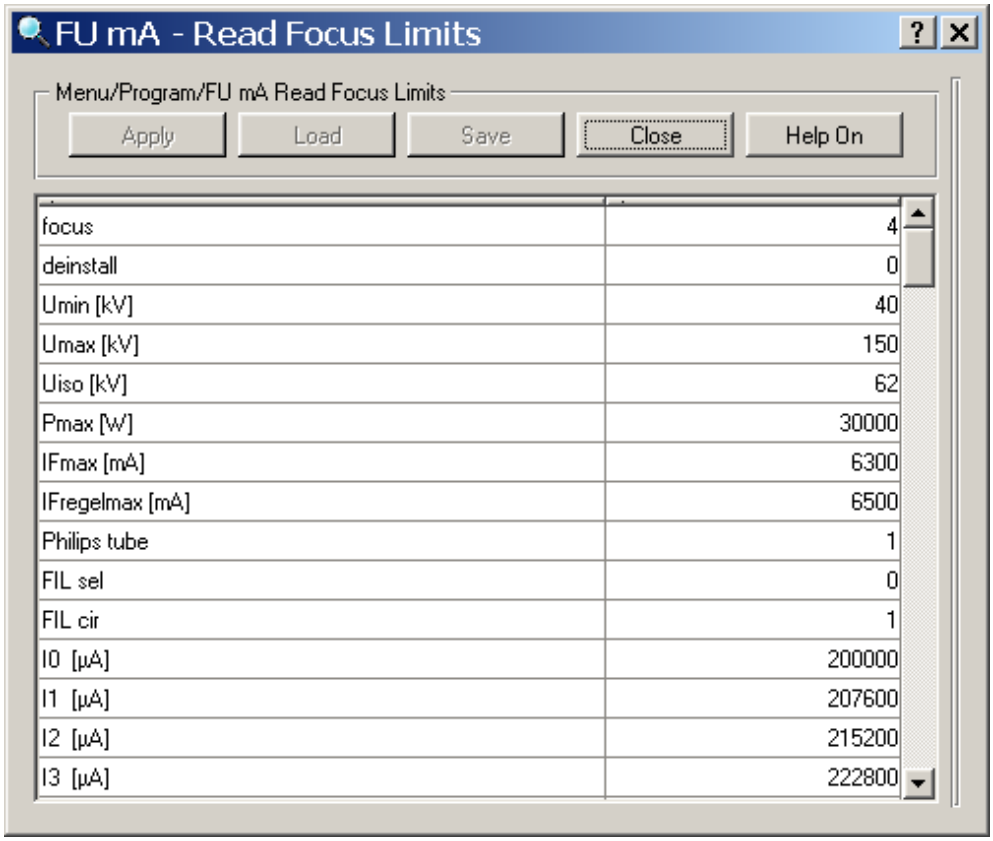
The U_{iso} value increased at the large focus (due to its problem) from 71kV to 76kV, it dropped from 73kV default to 62kV at the small focus.

Tables see next page.

large:

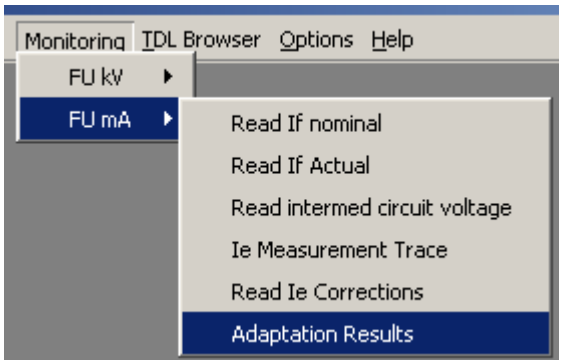

FU mA - Read Focus Limits
Menu/Program/FU mA Read Focus Limits
Apply
Load
Save
Close
Help On
focus 3
deinstall 0
Umin [kV] 40
Umax [kV] 150
Uiso [kV] 76
Pmax [W] 80000
IFmax [mA] 6740
IFregelmax [mA] 6940
Philips tube 1
FIL sel 0
FIL cir 2
I0 [µA] 431272
I1 [µA] 445724
I2 [µA] 460201
I3 [µA] 474726

small:

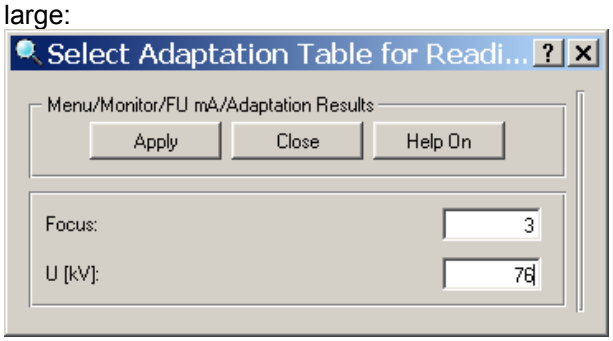

FU mA - Read Focus Limits
Menu/Program/FU mA Read Focus Limits
Apply
Load
Save
Close
Help On
focus 4
deinstall 0
Umin [kV] 40
Umax [kV] 150
Uiso [kV] 62
Pmax [W] 30000
IFmax [mA] 6300
IFregelmax [mA] 6500
Philips tube 1
FIL sel 0
FIL cir 1
I0 [µA] 200000
I1 [µA] 207600
I2 [µA] 215200
I3 [µA] 222800

A big amount of data is now present for both filaments. Tables for each kV stage within the min and max programmed kV values are available.

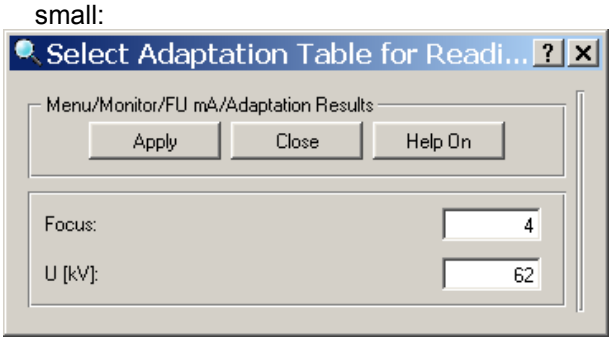
Path:



large:



small:



After typing in the filament number and the desired kV stage one gets the tables:

If [mA]	Ie	boost time	blank time
large focus	uA	ms	ms
+3156	+100	+0	+762
+3193	+131	+3	+733
+3230	+165	+7	+709
+3267	+201	+11	+689
+3304	+241	+14	+670
+3341	+288	+18	+650
+3378	+342	+21	+635
+3415	+404	+23	+619
+3452	+477	+26	+604
+3489	+561	+30	+589
+3526	+659	+32	+573
+3563	+771	+35	+559
+3600	+900	+38	+545
+3637	+1045	+40	+533
+3674	+1210	+41	+520
+3711	+1396	+45	+508
+3748	+1605	+48	+497
+3785	+1846	+51	+484
+3822	+2124	+53	+472
+3859	+2446	+56	+460
+3896	+2818	+59	+450
+3933	+3248	+62	+438
+3970	+3742	+65	+426
+4007	+4306	+68	+415
+4044	+4948	+72	+405
+4081	+5673	+73	+395
+4118	+6488	+76	+385

If [mA]	Ie	boost time	blank time
small focus	uA	ms	ms
+3189	+100	+0	+705
+3221	+124	+4	+681
+3253	+150	+8	+649
+3285	+177	+12	+631
+3317	+206	+16	+616
+3349	+239	+18	+601
+3381	+276	+23	+583
+3413	+318	+26	+567
+3445	+366	+27	+553
+3477	+420	+28	+539
+3509	+482	+33	+527
+3541	+553	+36	+512
+3573	+632	+38	+499
+3605	+721	+41	+487
+3637	+822	+43	+475
+3669	+933	+47	+463
+3701	+1058	+50	+451
+3733	+1199	+51	+440
+3765	+1360	+54	+429
+3797	+1544	+56	+419
+3829	+1753	+59	+407
+3861	+1991	+62	+396
+3893	+2262	+65	+385
+3925	+2569	+69	+374
+3957	+2914	+72	+363
+3989	+3301	+75	+353
+4021	+3733	+78	+343

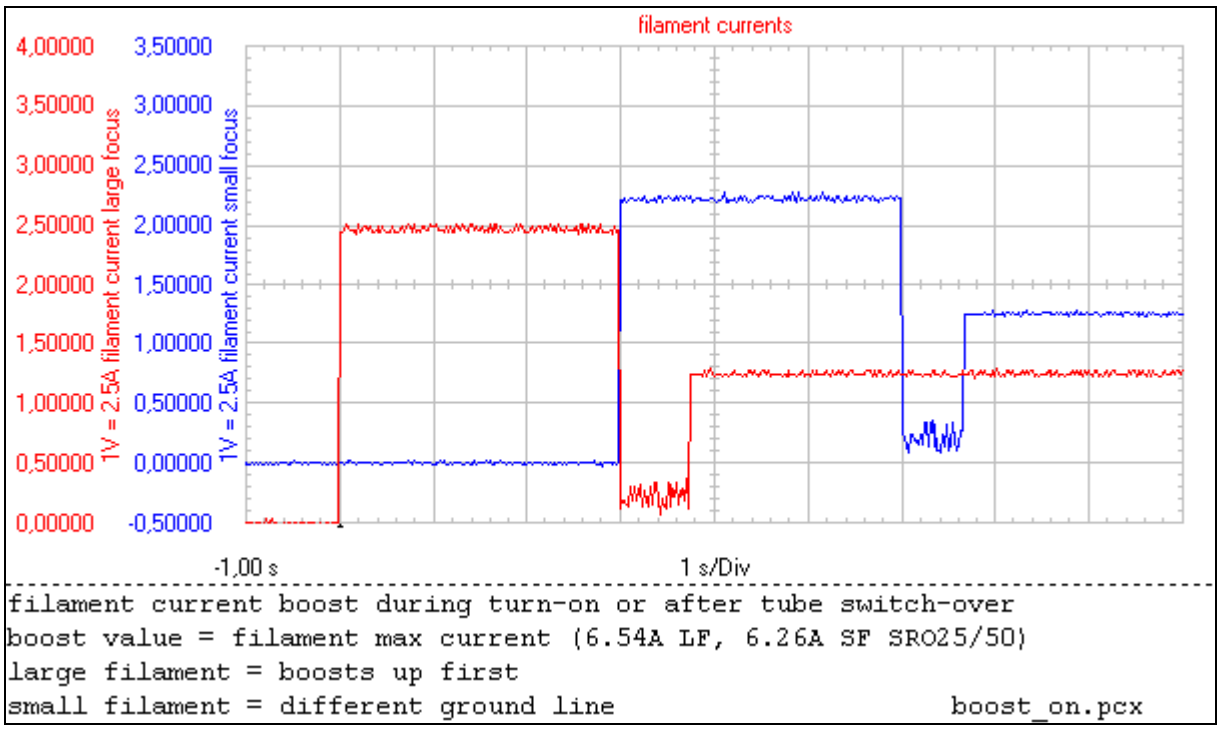
+4155	+7401	+79	+375
+4192	+8417	+82	+364
+4229	+9544	+85	+354
+4266	+10792	+87	+345
+4303	+12174	+90	+336
+4340	+13703	+93	+327
+4377	+15392	+95	+319
+4414	+17252	+98	+311
+4451	+19298	+100	+303
+4488	+21541	+103	+295
+4525	+23999	+106	+287
+4562	+26703	+108	+280
+4599	+29689	+110	+272
+4636	+32989	+114	+265
+4673	+36638	+117	+258
+4710	+40670	+119	+252
+4747	+45119	+121	+245
+4784	+50017	+125	+238
+4821	+55391	+127	+231
+4858	+61263	+130	+225
+4895	+67653	+133	+217
+4932	+74585	+136	+213
+4969	+82081	+140	+206
+5006	+90163	+142	+200
+5043	+98855	+144	+193
+5080	+108193	+148	+189
+5117	+118216	+151	+184
+5154	+128963	+153	+178
+5191	+140472	+157	+173
+5228	+152784	+159	+167
+5265	+165937	+161	+163
+5302	+179978	+166	+158
+5339	+194963	+169	+153
+5376	+210952	+171	+148
+5413	+228002	+175	+143
+5450	+246172	+177	+139
+5487	+265521	+181	+134
+5524	+286088	+183	+129
+5561	+307856	+188	+125
+5598	+330795	+190	+120
+5635	+354877	+194	+116
+5672	+380073	+197	+112
+5709	+406352	+200	+107
+5746	+433642	+204	+104
+5783	+461765	+207	+100
+5820	+490532	+211	+95
+5857	+519750	+214	+92
+5894	+549230	+218	+87
+5931	+578788	+222	+85
+5968	+608347	+224	+80
+6005	+637900	+228	+78
+6042	+667443	+233	+75
+6079	+696968	+236	+72
+6116	+726466	+240	+68
+6153	+755775	+245	+64

+4053	+4214	+82	+333
+4085	+4747	+86	+323
+4117	+5334	+88	+314
+4149	+5981	+91	+305
+4181	+6690	+92	+297
+4213	+7467	+96	+289
+4245	+8316	+99	+280
+4277	+9242	+102	+270
+4309	+10249	+104	+263
+4341	+11341	+107	+254
+4373	+12525	+110	+247
+4405	+13811	+113	+240
+4437	+15215	+115	+233
+4469	+16751	+117	+225
+4501	+18433	+120	+219
+4533	+20276	+123	+212
+4565	+22294	+127	+205
+4597	+24501	+129	+198
+4629	+26904	+131	+191
+4661	+29505	+135	+185
+4693	+32305	+138	+179
+4725	+35305	+140	+172
+4757	+38508	+143	+165
+4789	+41914	+147	+159
+4821	+45527	+150	+153
+4853	+49370	+152	+148
+4885	+53478	+156	+143
+4917	+57887	+158	+138
+4949	+62634	+161	+132
+4981	+67755	+164	+127
+5013	+73286	+168	+120
+5045	+79254	+171	+117
+5077	+85655	+174	+111
+5109	+92481	+177	+105
+5141	+99722	+181	+101
+5173	+107369	+184	+96
+5205	+115412	+186	+91
+5237	+123843	+190	+87
+5269	+132653	+194	+81
+5301	+141836	+196	+77
+5333	+151386	+199	+73
+5365	+161295	+203	+68
+5397	+171556	+206	+63
+5429	+182163	+209	+60
+5461	+193109	+213	+55
+5493	+204388	+217	+52
+5525	+215992	+220	+48
+5557	+227915	+224	+44
+5589	+240149	+226	+40
+5621	+252649	+231	+36
+5653	+265317	+236	+33
+5685	+278047	+240	+29
+5717	+290734	+244	+24
+5749	+303273	+247	+21
+5781	+315564	+251	+17

+6190	+784565	+249	+62	+5813	+327518	+257	+14
+6227	+812499	+253	+59	+5845	+339048	+262	+11
+6264	+839237	+259	+54	+5877	+350065	+266	+8
+6301	+864454	+264	+53	+5909	+360484	+272	+4
+6338	+887991	+271	+49	+5941	+370248	+275	+0
+6375	+909809	+277	+46				
+6412	+929875	+285	+43				
+6449	+948153	+292	+40				
+6486	+964641	+305	+38				
+6523	+979430	+317	+35				
+6560	+992629	+330	+32				
+6597	+1004346	+345	+30				
+6634	+1014725	+362	+25				
+6740	+1040003	+399	+0				

One can see that it takes about 2 times longer for the large filament temperature to cool down (blank time) compared to the boost up time.
The ratio for the small focus is about 2.5 times.

Once the adaptation process is finished the filament current the boost process during turn-on or after tube switch-over looks like this:



First the large, then the small focus will be boosted for 3 seconds with the **Ifmax** value from the default data table. Afterwards the filament current will be decreased to 500mA for a certain time (from the calculation table now present) to bring it down to the 100µA based standby filament temperature.

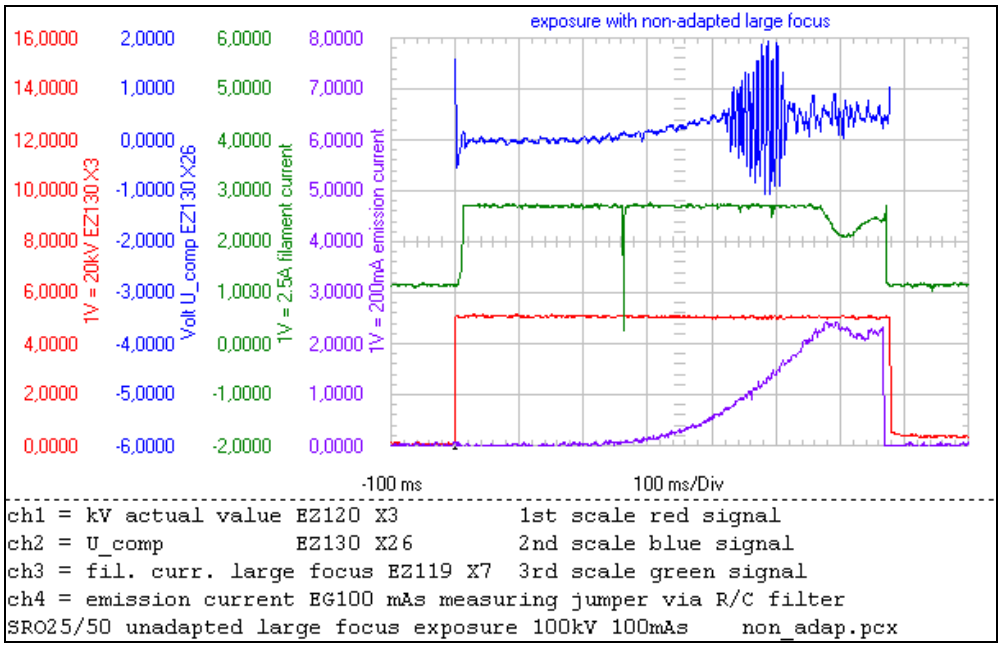
Only in this condition = both filaments adapted one might see at glass tubes that the filament is getting brighter with PREP.
Non-adapted filaments will not get a higher filament current with PREP.

Appendix A

mA_control EZ119 functions
conditioning mode

Systems with a non-adapted tube can be used at least with kV-mAs technique. The control desk displays “Test” in this condition.

It does not behave like the normal mAs technique with a constant mA value and the shortest time possible, but will get the user the required mAs and dose.



As one can see in the screenshot the filament current (green) jumps from 3A in PREP to the large focus filament current limit value 6.54A about 10ms after kV actual (red) is at its nominal value and **kV_control EZ130** has sent the X_ACT_S/ signal.

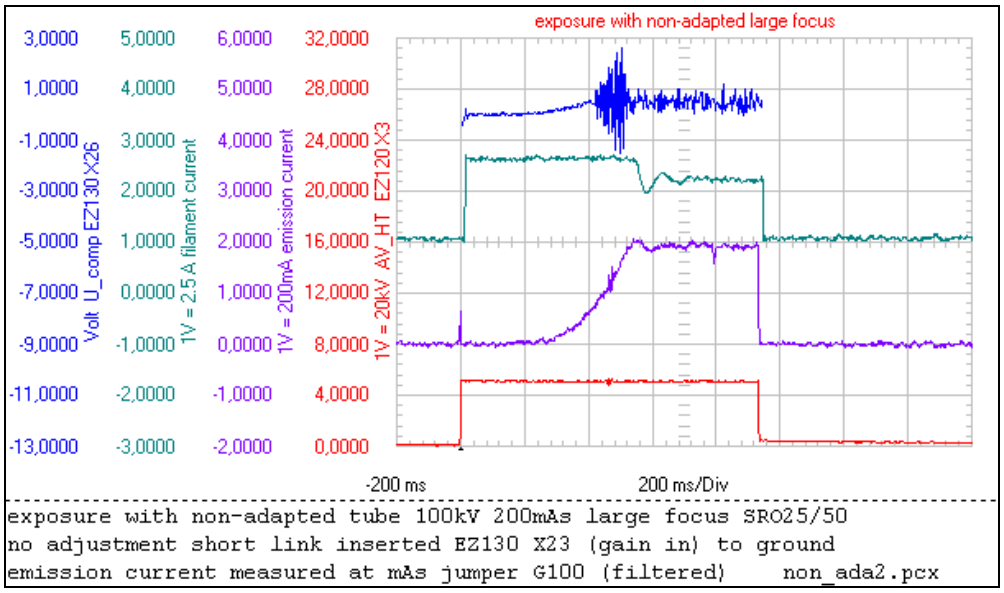
At 3A filament current the emission current is almost zero (< 100µA). Depending on the size and construction of the filament it takes quite a while before the temperature of the filament and with it the emission current (purple) rises.
If the emission current limit for the selected kV value is achieved the filament current will be reduced to keep the emission current at a constant value.
For all non-AEC techniques (kV-mAs, kV-mA-ms, kV-mAs-ms**) mA_control EZ119** always takes care about the termination of exposures once the set mAs value is achieved.

This technique can and should be used to condition the tube before it will be adapted during a non-preinstalled installation or after tube exchange.

The 4th signal (blue) of the screenshot displays the U_comp value (measured at the **kV_control EZ130** at release 3 generators only) to indicate that there is a lot of control to keep the kV at a constant level during a changing load.
Once the mA value is more or less stable U_comp is less busy.

The following screenshot shows the same, but instead of 100mAs for the first exposure 200mAs were set in this case. It results in a longer exposure time. Compared with the total exposure time it is only 250ms longer compared to the first exposure, which already took 675ms.
The reaction time to start with the emission of mA is the same, about 250ms.

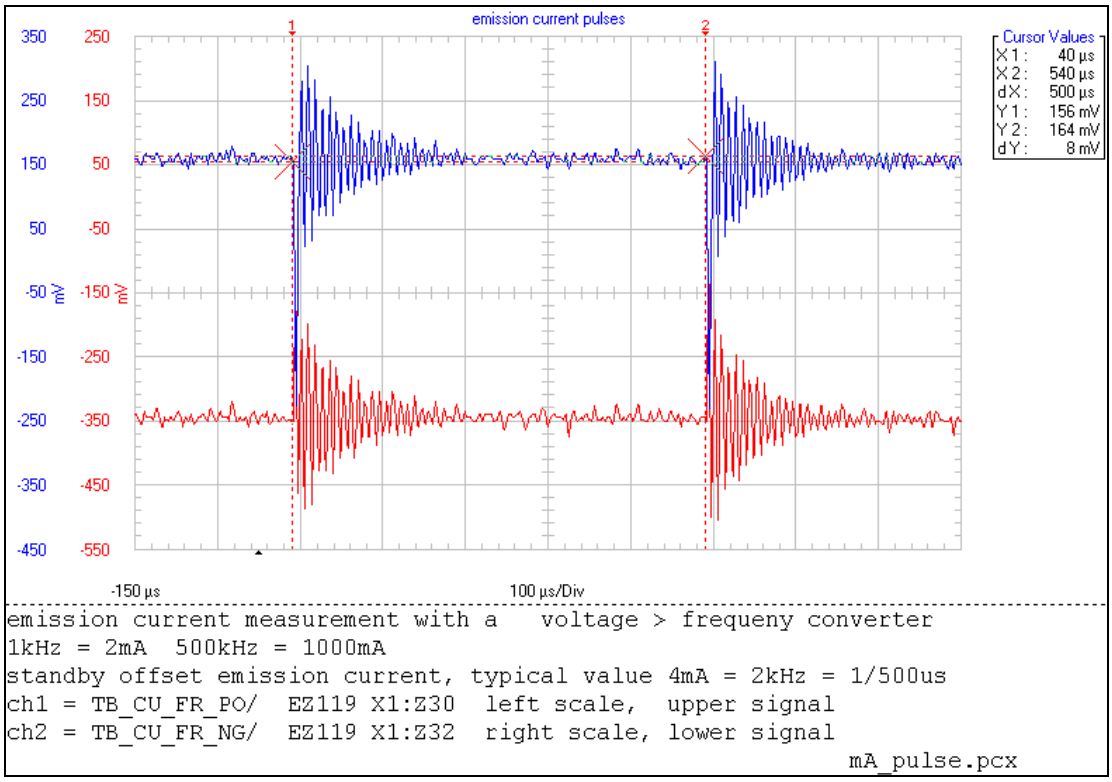
The emission current limit was set to 500mA in the first 100mAs exposure. For 200mAs it is limited to 400mA, otherwise the focus track will be overloaded.



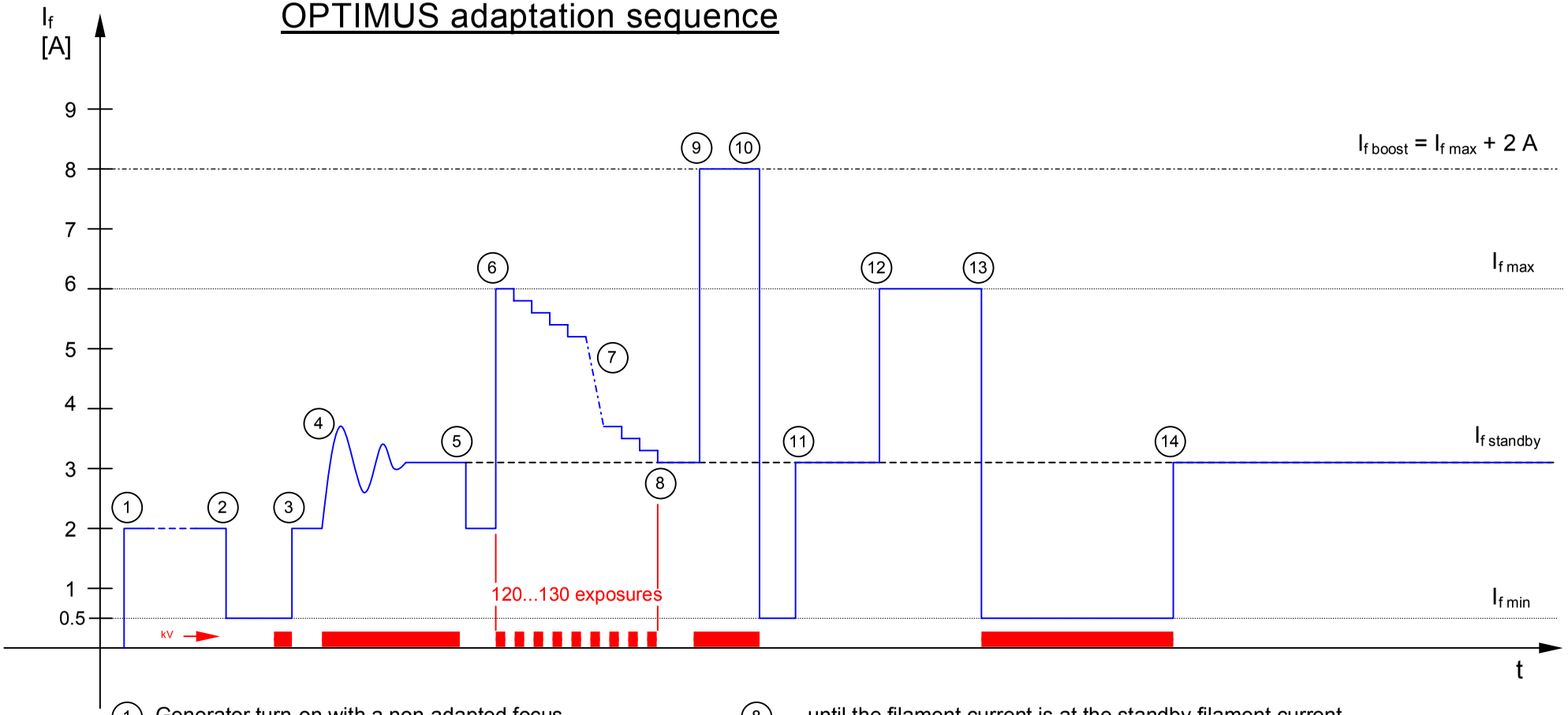
Warm-up or conditioning procedures must always be carried out with the large focus.
Some small filaments are very short. It takes so long to get it heated up to achieve an emission current that the generator errors out before any emission current appears.

Appendix B

Waveform of the offset "standby emission current"



OPTIMUS adaptation sequence



1. Generator turn-on with a non-adapted focus.
2. Adaptation start, measuring of the 4mA standby offset ...
3. ... emission current and offset mA of the kV meas. circuit.
4. Measuring of the individual standby filament current ...
5. ... based on 100µA emission current, 6 seconds exposure.
6. Measuring of the kV dependent emission currents ...
7. ... starting at the max filament current with decrements ...
8. ... until the filament current is at the standby filament current.
9. Measuring of the positive boost time to get the filament temperature...
10. ... = mA up from standby to achieve the selected mA value.
11. Timeout at 500mA to get the filament temperature down.
12. The filament is heated up with its max current, then the cooling ...
13. ... behavior (negative boost) takes place to measure the time...
14. ... it takes to decrease the mA down to its basic value of 100µA